

## SUMMARY

of PhD thesis:

### RESEARCH REGARDING THE OBTAINING OF SOME BAKERY PRODUCTS BASED ON CEREALS AND PSEUDOCEREALS

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This PhD thesis “**Research regarding the obtaining of some bakery products based on cereals and pseudocereals**” has been written within the doctoral school for “Engineering and Management of Vegetal and Animal Resources” of the University of Agricultural Sciences and Veterinary Medicine of Bucharest.

Attention has been paid during the latest years to the health of the population which is encouraged to eat healthy food. The life style of the population has changed and there is a trend to eat products that bring nutritional benefit and low sugar intake, so the PhD thesis entitled „**Research of the obtaining of some bakery products based on cereals and pseudocereals**” has as primary goal to obtain new bakery products based on *Avena nuda* L. and *Amaranthus sp.* with nutritional benefits upon consumers and complying with the safety and security food requirements. Experiments have been made for this PhD thesis to obtain both conventional products (biscuits, pasta) and special products, gluten-free and sugar-free.

Classic analysis methods and new, modern and non-destructive (non-invasive) methods have been used for this PhD thesis, that are quick and friendly with the environment, to prove that similar results can be obtained with less consumption of reagents, energy and time. These techniques (ex. NMR, FT-IR, UV-VIS) are quick, have low cost and give lots of information through a single test, rendering them suitable for on-line control and/or process –level control.

**Four main objectives** have been defined and achieved for this PhD thesis:

1. Analysis of the current stage of the research on the evolution, farming and use of cereals (oat especially) and pseudocereals (*Amaranthus* especially) in bakery products. Current stage of the research on the properties of essential oils and their use in food products.

2. Use of *Avena nuda* L. and *Amaranthus sp.* through three food matrixes: two conventional (biscuits and pasta) and one matrix with low contents in gluten or gluten-free and vegan, their testing with various methods of analysis (classic and modern) to establish the

nutritional composition, sensorial properties, texture, acceptability by consumers and food safety.

3. Analysis and testing of essential oil of *Mentha arvensis*, *M. piperita* and *M. spicata* upon the packaging of a food matrix obtained for this PhD thesis in order to extend its shelf life.

4. Conclusions and recommendations resulted from the research conducted.

The PhD thesis has been structured according to the norms in force. It includes 10 chapters, 216 pages, 88 tables, 161 figures and 162 references.

**Chapter I „Current status of knowledge”** gives information from the specialized literature on the current status of the oat farming at national and international level as well as the current status of the use of oat and pseudocereals (especially *Amaranthus* in conventional bakery products and gluten-free products, for people with special nutrition. The current status of the research on the properties of essential oils and their uses has been also presented in this chapter. As sources, I have used specialized scientific publications and articles, handbooks, books, official websites (Ministry of Agriculture and Rural Development, Romanian Statistic Annuary, FAO etc).

**Chapter II „Objectives of the research, material and research methods used”** includes: the main goal, the objectives of the research, the biologic material studied and the analysis methods used for this PhD thesis. The raw material has been obtained, namely *Avena nuda* L. and *Amaranthus sp.* The research methods used for the analysis of common oat (with bran), analysis of the fat (lipids) from the biologic material studies and the analysis of the food matrix obtained have been presented.

**Chapter III „Natural and institutional environment of the research”** presents the natural and institutional environment of the experimental research during the PhD study program conducted within the Doctoral School for the Engineering and Management of Vegetal and Animal Resources, Agronomy field, of the University of Agricultural Sciences and Veterinary Medicine of Bucharest. The research presented in this PhD thesis has been conducted in the Experimental Field of the Faculty of Agriculture in the School Farm in Moara Domneasca (Ilfov county), the Research Centre for Sustainable Agriculture, the Pilot Station for the Processing of Cereals and Flours and in the labs for food products analysis of the National Institute for Research-Development for Food Bio-resources IBA-Bucharest.

This chapter also presents the climate during the agricultural years where *Avena sativa*, *Avena nuda* L. and *Amaranthus sp.* were grown to obtain raw materials for experiments.

**Chapter IV „Results in obtaining the raw material from *Avena sp.* and *Amaranthus sp.*”** presents results about the farming and the crops for the main raw material (oat and amaranth) used in experiments to obtain bakery products for this PhD thesis. The crops were 2,879 kg/ha of *Avena sativa*, 3,568 kg/ha *Avena nuda* L. and *Amaranthus* seeds was 1,863 kg/ha in Burgundi and 3,027 kg/ha in Golden.

**Chapter V „Results regarding the analysis of *Avena sp.* and *Amaranthus sp.* crops”** presents results after characterizing the various kinds of oat, varieties of *Amaranthus*, used in experiments to obtain bakery products. For a full characterization and for a food matrix that is safe for human consumption, microbiologic tests have been performed.

To give an image of the qualitative and nutritional characteristics of the various sources of oat, **subchapter 5.1 „Characterization of kinds of oat”** presents the analysis of six kinds of oat, four kinds of conventional oat (*Avena sativa*) and two kinds of naked oat (*Avena nuda* L.). The samples have been tested from physical and chemical points of view (humidity, protein, ashes, brute fiber, fat) in terms of metal and mineral contents, sensorial print, aminoacids, gluten, gliadin and deoxynivalenol. The results were statistically processed through Principal Components Analysis (PCA).

**Subchapter 5.2 „Research on the comparative analysis of certain cereals and pseudocereals”** presents the tests of ten samples of cereals and pseudocereals through various methods (classic and modern): six samples of oat, three samples of amaranth and one sample of wheat. Most samples were grown in the Experimental Field in the School and Experimental Farm in Moara Domnească, Ilfov. The results were processed statistically through Principal Components Analysis (PCA) and hierarchical cluster analysis (HCA). Compositional differences among cereals and between cereals and pseudocereals have been noticed. The *Amaranthus* sample, the Alegria type had the highest protein content of 20.49%, which is close to the one in oat.

Regarding the content of calcium in the analyzed samples, we noticed that the *Amaranthus* seeds had the highest content of 179.76 mg/100 g, in the Alegria type while the wheat sample had a content of calcium 5 times lower.

**Subchapter 5.3 „Characterization through spectroscopy  $^1\text{H-NMR}$ , of *Amaranthus* genotypes grown between 2011-2013”** presents results about the characterization through spectroscopy  $^1\text{H-NMR}$ , of 8 genotypes of *Amaranthus* grown between 2011-2013. Differences in terms of saturated fatty acids, bi-unsaturated and saturated depending on the year when they are grown and the type analyzed.

**Chapter VI „Results regarding the obtaining of biscuits based on oat”** contains results regarding the analysis of products through various methods for a full characterization.

**Subchapter 6.1 „Establishing of rheological properties of flours used to obtain biscuits with oat flour bought from the market”** analyzed the empirical rheological properties of the doughs made of various flours and mixes of flours by using the Mixolab equipment, that were used to obtain the biscuits. Baking tests were made, by using semi-white wheat flour (type 900) and whole-oat flour bought from the market, to establish the recipe and the best production parameters.

**Subchapter 6.2 „Preliminary study regarding the testing of the behavior of the oat flour during the obtaining of food matrixes”** presents results of the analysis of 3 samples of biscuits: a blank test with wheat flour type 900, a sample with 50% oat flour and a sample with 100% oat flour. The samples were analyzed from the physical and chemical points of view, content of beta-glucan, metals and minerals. The results of the descriptive sensorial analysis showed that the sample of biscuits made of oat flour obtained a satisfactory score (14.22), which means that the oat flour alters (for the worse) the organoleptic properties of the product.

**Subchapter 6.3 „Establishing the rheological properties of the flours used to obtain biscuits with oat flour *Avena nuda* L.”** presents the results of the analysis of the empirical rheological properties of the doughs made of various flours and mixes of flours by using the Mixolab equipment, that were used to obtain biscuits with flour made of oat grown in the Experimental Field in the School Farm of Moara Domnească.

**Subchapter 6.4 „Results regarding the obtaining of biscuits based on oat flour of *Avena nuda* L. kind”** presents the results obtained from the analysis of 5 samples of biscuits obtained from various percentages (P1-0%, P2-25%, P3-50%, P4-75% si P5-100% ) of oat flour type *Avena nuda* L. grown in Moara Domnească. The samples were analyzed in terms of physical and chemical parameters (humidity, fat, protein, ashes, sugar and cellulose), content of cellulose, total food fiber, mineral elements (Ca, Fe, Mg, K, Na, Zn, Se, Cu, Mn), acrylamide, fatty acids and microbiologic acids (yeasts and molds).

The samples fell within normal limits in terms of microbes and acrylamide. According to the descriptive sensorial analysis, when the oat flour *Avena nuda* L. increased in the recipe, the organoleptic properties of the biscuits samples altered in a negative sense. According to the results obtained, the percentage of oat flour *Avena nuda* L. added in the recipe can be 75% maximum so that the product could be accepted by consumers and could fall in the category „good”.

**Chapter VII „Results regarding the obtaining of pasta from various flours”** has 3 subchapters.

**Subchapter 7.1 „Obtaining and establishing the type of pasta modeling”** presents the technological procedure to obtain pasta. Experiments on 4 types of flours: semi-white wheat flour, flour from the market, flour of oat *Avena nuda* L. and flour of *Amaranthus* have been conducted. It has been established that the flours analyzed can be used to model tagliateli pasta.

**Subchapter 7.2 „Results regarding the compositional analysis of pasta”** presents results obtained from the analysis of compositional parameters (humidity, content of protein, fat, ashes, cellulose, fatty acids, content of metals and minerals) and structural parameters (texture, color) of pasta. The results about gluten and gliadin showed that only the sample of pasta made of *Amaranthus* flour falls in the category of gluten-free products.

**Subchapter 7.3 „Results of physical analysis of pasta (texture and colour)”** presents data obtained from the analysis of the texture of pasta before boiling (resistance to tearing and compression) and after boiling (firmness and elasticity). The samples have been analyzed also in terms of colour parameters: L, a\*, b\*, C\*-chromaticity and h\*nuance.

**Chapter VIII „Results regarding the obtaining of bars with Amaranthus supplement”** presents the results obtained after establishing vegan food matrixes (bars) based on oat flakes with *Amaranthus* supplement (seeds, *Amaranthus* flour), and their analysis through various methods for full characterization.

**Subchapter 8.1 „Experimental tests to establish the bar recipe”** contains preliminary data to establish the bar recipe based on oat and *Amaranthus*, aiming at replacing the oat flakes with *Amaranthus* seeds/flour. Several experimental versions have been performed to establish the final recipe of bars with oat flakes and *Amaranthus* seeds/flour. The conclusion was that the product should contain *Amaranthus* flour (not seeds), should have a final mass of  $40\pm 5$  g, 8 cm length, 3 cm width and 1 cm thickness.

**Subchapter 8.2 „Experimental versions to obtain bars with Amaranthus flour”** presents the experimental versions performed to obtain bars, which aimed at replacing the oat flakes in the recipe with *Amaranthus* flour. Experimental versions have been performed where the oat flakes have been replaced with 20% *Amaranthus* (V1) flour, 40% *Amaranthus* (V2) flour and 60% *Amaranthus* (V3) flour. A blank test has been performed (M), with 100% oat flakes.

The experimental versions obtained have been analyzed in terms of composition (physical and chemical analysis, content of metals and minerals, polyphenols, antioxidant capacity, acrylamide, gluten and gliadin) and physical characteristics (texture and colour).

After determining the content of acrylamide, we found that the recommended value (150 µg/kg) for this type of products is far from reached, which means that all the bar samples achieved are safe for human consumption. The microbiologic results also showed that the samples are compliant from the microbiologic point of view. After determining the gluten and gliadin, the samples fell in the category: “*gluten-free product*”. Both the preferential sensorial analysis and the descriptive analysis revealed that when the amount of *Amaranthus* flour increased in the recipe, the preference of the assessor for the product diminished gradually, so that the bar with 60% *Amaranthus* flour obtained the lowest score in both tests.

This chapter also analyzed the permeability and the migration of the two types of films used to pack the bars. After computing the economic efficiency for each experimental versions made, we found that the bars obtained have a price that is close to the one on the market for the same category, even lower in some cases.

**Chapter IX „Analysis, selection and use of mint essential oil in packing the bar with *Amaranthus* flour”** presents the results obtained through analysis, selection and testing of 3 essential oils: *Mentha arvensis*, *M. piperita* and *M. spicata*, in order to choose the right oil to help extend the validity of the bars with *Amaranthus* flour. A method to dose the major components in the mint essential oil through spectroscopy <sup>1</sup>H-NMR has been developed, validated and used. The oils were tested in terms of antimicrobial capacity and the minimal inhibiting concentration was established, that later on was used to spray the packaging of the bar made with *Amaranthus* flour. An extension of the validity of the bars from 10 to 14 months was achieved in the case of the triple layered film (PE/EVOX/PP) and from 8 to 10 months in the case of the single layered film (BOPP).

**Chapter X „Conclusions and recommendations”** presents the conclusions of the research conducted and the recommendations resulted. The research results into the recommendation to grow oat *Avena nuda* L., because, unlike *Avena sativa*, it does not need shelling.

The raw materials in the Experimental Field in Moara Domnească (oat and amaranth) complied in terms of quality, composition and microbiology. Both in the case of oat (type *Avena nuda* L.) and *Amaranthus* good quantitative and qualitative crops can be obtained so that they could be introduced in the food production.

Both oat and *Amaranthus* have special nutritional properties and can be used to obtain new bakery products (biscuits, pasta, bars) that can bring high nutritional intake compared with the products based on wheat. Two conventional products have been developed (biscuits and pasta) and a vegan product, gluten-free, sugar-free, based on oat flakes and *Amaranthus*.

The essential oil of *Mentha spicata* has higher antimicrobial capacity than *M. piperita* and *M. arvensis*. In a concentration of 1:5 essential oil of *Mentha spicata* in 10% ethanol can be used to spray the packaging to extend the shelf life of the packed product.

The results obtained for this PhD thesis have been used to publish **3 scientific articles as primary author** in indexed and **ISI** journals and to participate in **1 international congress** and **3 national conferences**.